

## Two-Wire Hall-Effect Switch with Advanced Diagnostics

### FEATURES AND BENEFITS

- Functional safety
  - Developed in accordance with ISO 26262:2011 (pending assessment)
  - Designed to meet ASIL B requirements
  - Integrated background diagnostics for:
    - Signal path
    - Regulator
    - Hall plate and bias
    - Overtemperature detection
    - Nonvolatile memory
  - Defined fault state
- Multiple product options
  - Magnetic polarity, switch points, and hysteresis
  - Temperature coefficient
  - Output polarity
- Reduces module bill-of-materials (BOM) and assembly cost
  - ASIL B sensor can replace redundant sensors
  - Integrated overvoltage clamp and reverse-battery diode
- Automotive-grade ruggedness and fault tolerance
  - Extended AEC-Q100 Grade 0 qualification
  - Operation to 175°C junction temperature
  - 3 to 30 V operating voltage range
  - ±8 kV HBM ESD
  - Overtemperature indication

### PACKAGES



Not to scale

### DESCRIPTION

The APS11800 is a two-wire planar Hall-effect sensor integrated circuit (IC) developed in accordance with ISO 26262:2011. It includes internal diagnostics and a fault state that support a functional safety level of ASIL B when integrated and used in conjunction with the appropriate system-level control. The two-wire interface provides interconnect open/short diagnostics and a fault state to communicate diagnostic information while maintaining compatibility with legacy two-wire systems. The continuous background diagnostics are transparent to the host system and results in a reduced fault tolerant time.

The APS11800 product options include magnetic switch points, temperature coefficient, magnetic and output polarity. The switch points are configured for a stable or flat temperature response. Additional temperature response characteristics for NdFeB or low-cost ferrite magnets may be available by contacting Allegro MicroSystems. For situations where a functionally equivalent two-wire latch device is preferred, refer to the APS12800.

*Continued on next page...*

### APPLICATIONS

- Automotive and industrial safety systems
- Limit switches and safety interlocks
- Seat position detection
- Seat belt buckles
- Hood/trunk/door latches
- Transmission pawl, fork, piston, valve, gear position detection

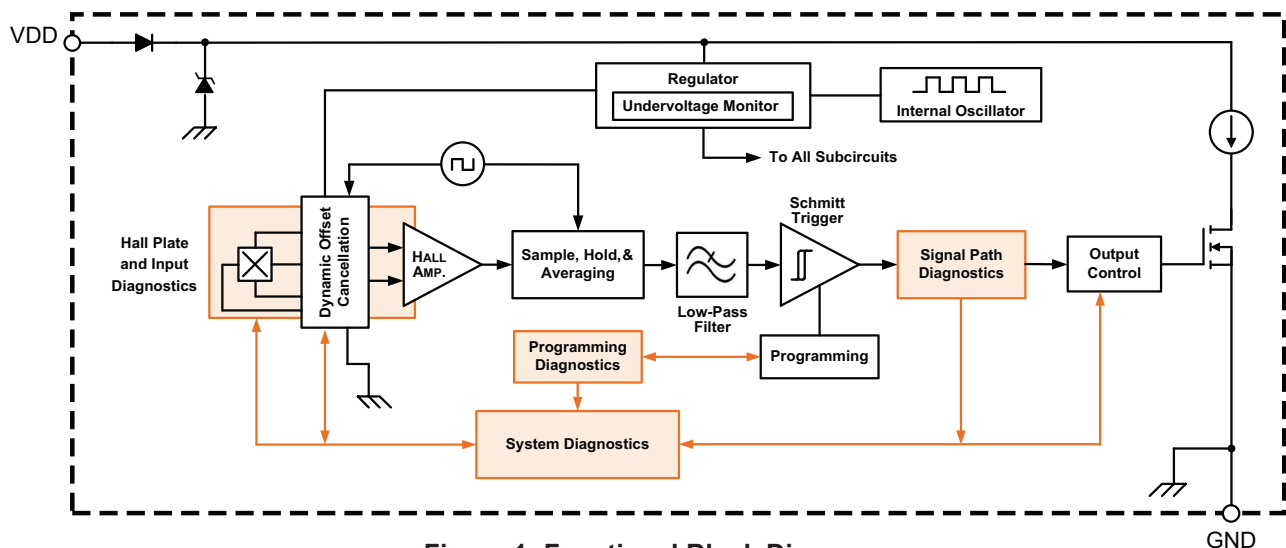


Figure 1: Functional Block Diagram

## DESCRIPTION (continued)

APS11800 sensors are engineered to operate in the harshest environments with minimal external components. They are qualified beyond the requirements of AEC-Q100 Grade 0 and will survive extended operation at 175°C junction temperature.

These monolithic ICs include on-chip reverse-battery protection, overvoltage protection (e.g., 40 V load dump), ESD protection, overtemperature detection, and an internal voltage regulator for

operation directly from an automotive 12 V battery system. These integrated features reduce the end-product bill-of-materials (BOM) and assembly cost.

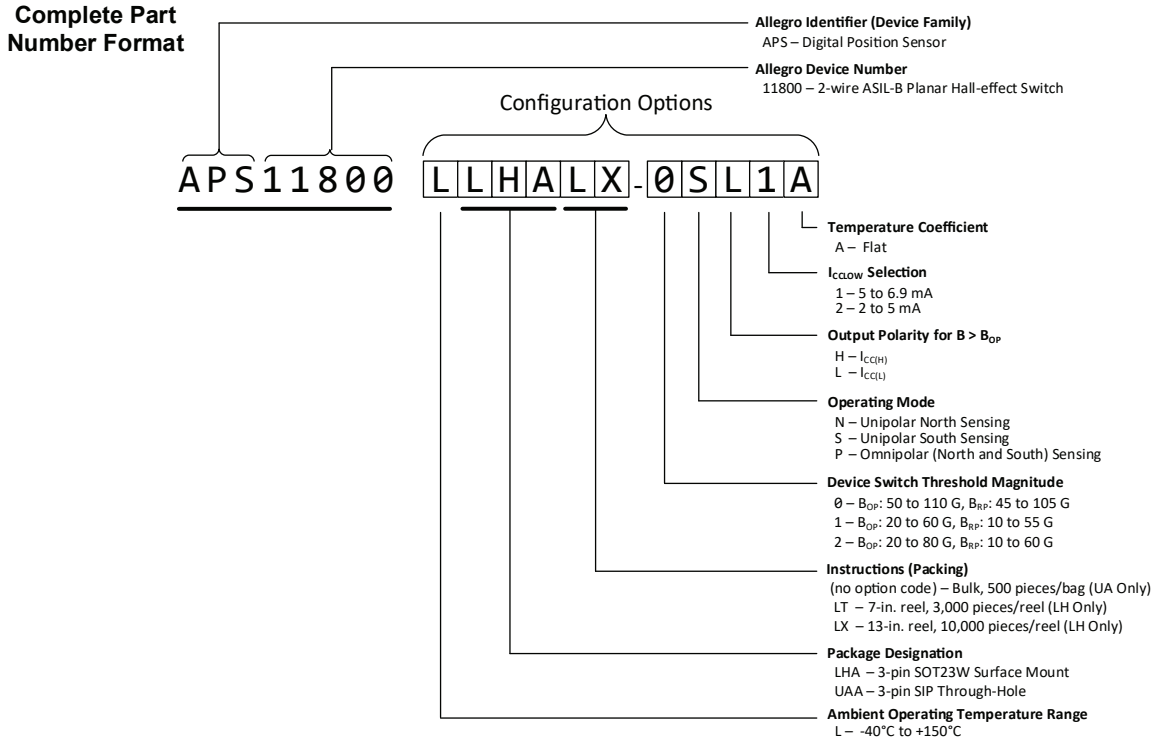
Package options include industry-standard surface-mount SOT (LH) and through-hole SIP (UA) packages. Both packages are RoHS-compliant and lead (Pb) free with 100% matte-tin-plated leadframes.



## SELECTION GUIDE [1]

| Part Number          | Package                     | Packing                         | Magnetic Temperature Coefficient | Operating Mode | Output Polarity for $B > B_{OP}$ | Device Switch Threshold Magnitude (G)         | $I_{CC(L)}$ Selection (mA) |
|----------------------|-----------------------------|---------------------------------|----------------------------------|----------------|----------------------------------|---|----------------------------|
| APS11800LLHALT-0SH1A | 3-pin SOT23-W surface mount | 7-inch reel, 3000 pieces/reel   | Flat                             | Unipolar South | $I_{CC(H)}$                      | $B_{OP}$ : 50 to 110;<br>$B_{RP}$ : 45 to 105 | 5 to 6.9                   |
| APS11800LLHALX-0SH1A | 3-pin SOT23-W surface mount | 13-inch reel, 10000 pieces/reel |                                  |                |                                  |   |                            |
| APS11800LLHALT-0SL1A | 3-pin SOT23-W surface mount | 7-inch reel, 3000 pieces/reel   | Flat                             | Unipolar South | $I_{CC(L)}$                      | $B_{OP}$ : 50 to 110;<br>$B_{RP}$ : 45 to 105 | 5 to 6.9                   |
| APS11800LLHALX-0SL1A | 3-pin SOT23-W surface mount | 13-inch reel, 10000 pieces/reel |                                  |                |                                  |   |                            |
| APS11800LUAA-0SH1A   | 3-pin SIP through-hole      | Bulk, 500 pieces/bag            | Flat                             | Unipolar South | $I_{CC(H)}$                      | $B_{OP}$ : 50 to 110;<br>$B_{RP}$ : 45 to 105 | 5 to 6.9                   |
| APS11800LUAA-0SL1A   | 3-pin SIP through-hole      | Bulk, 500 pieces/bag            | Flat                             | Unipolar South | $I_{CC(L)}$                      | $B_{OP}$ : 50 to 110;<br>$B_{RP}$ : 45 to 105 | 5 to 6.9                   |

[1] Contact Allegro MicroSystems for options not listed in the standard selection guide.



## ABSOLUTE MAXIMUM RATINGS

| Characteristic                        | Symbol              | Notes      | Rating     | Unit |
|---------------------------------------|---------------------|------------|------------|------|
| Forward Supply Voltage <sup>[1]</sup> | V <sub>CC</sub>     |            | 45         | V    |
| Reverse Supply Voltage <sup>[1]</sup> | V <sub>RDD</sub>    |            | -30        | V    |
| Maximum Junction Temperature          | T <sub>J(MAX)</sub> |            | 165        | °C   |
|                                       |                     | 1000 hours | 175        | °C   |
| Storage Temperature                   | T <sub>stg</sub>    |            | -65 to 170 | °C   |

<sup>[1]</sup> This rating does not apply to extremely short voltage transients such as Load Dump and/or ESD. Those events have individual ratings, specific to the respective transient voltage event.

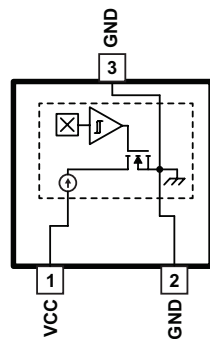
## ESD PERFORMANCE

| Characteristic | Symbol                | Notes                         | Rating | Unit |
|----------------|-----------------------|-------------------------------|--------|------|
| AEC-Q100 ESD   | V <sub>ESD(HBM)</sub> | Human Body Model AEC-Q100-002 | ±8     | kV   |

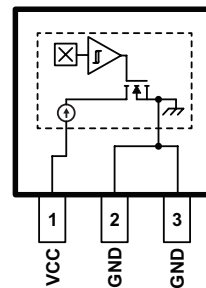
**TRANSIENT PROTECTION CHARACTERISTICS:** Valid for  $T_A = 25^\circ\text{C}$  and  $C_{BYP} = 0.1 \mu\text{F}$  (unless otherwise specified)

| Characteristics                    | Symbol    | Test Conditions              | Min. | Typ. | Max. | Unit |
|------------------------------------|-----------|------------------------------|------|------|------|------|
| Forward Supply Zener Clamp Voltage | $V_Z$     | $I_{CC(max)} + 3 \text{ mA}$ | 44   | –    | –    | V    |
| Reverse Supply Zener Clamp Voltage | $V_{RCC}$ | $I_{CC} = -1 \text{ mA}$     | –    | –    | -30  | V    |
| Reverse Supply Current             | $I_{RCC}$ | $V_{RCC} = -30 \text{ V}$    | –    | –    | -5   | mA   |

## PINOUT DIAGRAMS AND TERMINAL LISTS



**Package LH, 3-Pin  
SOT23W Pinout**



**Package UA, 3-Pin  
SIP Pinout**

### Terminal List Table

| Symbol | Pin Number |            | Description    |
|--------|------------|------------|----------------|
|        | LH Package | UA Package |                |
| VCC    | 1          | 1          | Supply Voltage |
| GND    | 2*         | 2          | Ground         |
| GND    | 3*         | 3          | Ground         |

\* Pins 2 and 3 are tied together internally and the device will operate with either pin 2 or 3 grounded externally; however, grounding both pins externally is recommended for EMC robustness.

**OPERATING CHARACTERISTICS:** Valid over full operating voltage and ambient temperature ranges for  $T_J < T_{J(max)}$ , and  $C_{BYP} = 0.1 \mu F$ , unless otherwise specified

| Characteristics                   | Symbol      | Test Conditions   | Min.        | Typ. [1] | Max. | Unit         |
|-----------------------------------|-------------|---|-------------|----------|------|--------------|
| Supply Voltage                    | $V_{CC}$    | Operating; min. $V_{CC}$ for magnetically actuated output                                     | 3           | –        | 30   | V            |
| Undervoltage Lockout              | $V_{UVLO}$  | Voltage threshold at which the device output is set to POS during power down                  | –           | 2.3      | –    | V            |
| Shutdown Voltage                  | $V_{SD}$    | Sensor output shuts down  | –           | 1.8      | –    | V            |
| Supply Current                    | $I_{CC(L)}$ | $I_{CCLOW}$ Selection = 2   | 2           | –        | 5    | mA           |
|                                   |             | $I_{CCLOW}$ Selection = 1   | 5           | –        | 6.9  | mA           |
|                                   | $I_{CC(H)}$ |   | 12          | –        | 17   | mA           |
|                                   | $I_{FAULT}$ | Safe current state; indicates device diagnostics have detected a fault condition; see Table 1 | 0.2         | –        | 1.8  | mA           |
| Output Slew Rate                  | dI/dt       | Standard circuit; $C_{BYP} = 100 \text{ nF}$ , $C_L$ [2] = 20 pF, $R_{SENSE} = 100 \Omega$    | –           | 0.4      | –    | mA/ $\mu$ s  |
|                                   |             | Min. circuit; $C_{BYP} = 10 \text{ nF}$ , $C_L$ [2] = 20 pF, $R_{SENSE} = 100 \Omega$         | –           | 4        | –    | mA/ $\mu$ s  |
| Power-On Time [3]                 | $t_{PO}$    | On power up only; time starts when supply voltage exceeds $V_{CC(min)}$                       | –           | –        | 70   | $\mu$ s      |
| Power-On State [4]                | POS         | Output state during power on; valid only when $V_{CC} \geq V_{CC(min)}$                       | $I_{CC(H)}$ | –        | –    | mA           |
| Chopping Frequency                | $f_C$       |   | –           | 800      | –    | kHz          |
| <b>Diagnostic Characteristics</b> |             |   |             |          |      |              |
| Fault Reaction Time               | $t_{DIAG}$  | $C_{BYP} = 0.1 \mu F$ , $R_{SENSE} = 100 \Omega$  | –           | 44       | –    | $\mu$ s      |
| Diagnostic Fault Retry Time       | $t_{DIAGF}$ |   | –           | 2        | –    | ms           |
| Overtemperature Shutdown          | $T_{JF}$    | Temperature increasing  | –           | 205      | –    | $^{\circ}$ C |
| Overtemperature Hysteresis        | $T_{HYS}$   |   | –           | 25       | –    | $^{\circ}$ C |

[1] Typical data is at  $T_A = 25^{\circ}\text{C}$  and  $V_{CC} = 12 \text{ V}$ , unless otherwise noted; for design information only.

[2]  $C_L$  – measurement probe capacitance.

[3] Measured from  $V_{CC} \geq V_{CC(min)}$  to valid output.

[4] Power-on state is defined only when  $V_{CC}$  slew rate  $> 6 \text{ V/ms}$ .

**MAGNETIC CHARACTERISTICS:** Valid over full operating voltage and ambient temperature ranges for  $T_J < T_{J(max)}$ , and  $C_{BYP} = 0.1 \mu F$ , unless otherwise specified

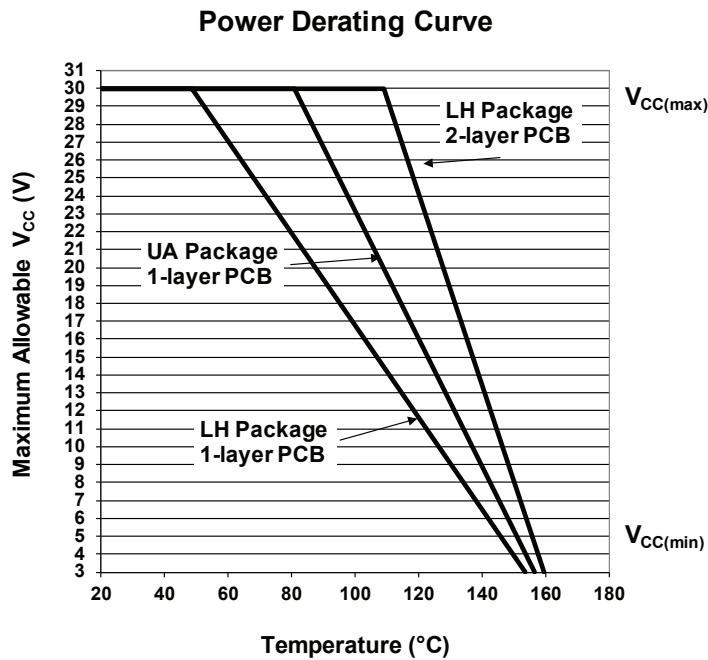
| Characteristics                      | Symbol    | Magnetic Switch-point Option | Temperature Coefficient | Test Conditions                      | Min. | Typ. [1] | Max. | Unit [2] |
|--------------------------------------|-----------|------------------------------|-------------------------|--------------------------------------|------|----------|------|----------|
| <b>Magnetic Characteristics</b>      |           |                              |                         |                                      |      |          |      |          |
| Operate Point                        | $B_{OP}$  | -0                           | A – Flat                | $T_A = -40^\circ C$ to $150^\circ C$ | 50   | –        | 110  | G        |
|                                      |           | -1                           | A – Flat                | $T_A = -40^\circ C$ to $150^\circ C$ | 20   | –        | 60   | G        |
|                                      |           | -2                           | A – Flat                | $T_A = -40^\circ C$ to $150^\circ C$ | 20   | –        | 80   | G        |
| Release Point                        | $B_{RP}$  | -0                           | A – Flat                | $T_A = -40^\circ C$ to $150^\circ C$ | 45   | –        | 105  | G        |
|                                      |           | -1                           | A – Flat                | $T_A = -40^\circ C$ to $150^\circ C$ | 10   | –        | 55   | G        |
|                                      |           | -2                           | A – Flat                | $T_A = -40^\circ C$ to $150^\circ C$ | 10   | –        | 60   | G        |
| Hysteresis                           | $B_{HYS}$ | All                          | All                     | $T_A = -40^\circ C$ to $150^\circ C$ | 5    | –        | 30   | G        |
| Switch Point Temperature Coefficient | $T_C$     | All                          | A - Flat                | $T_A = -40^\circ C$ to $150^\circ C$ | –    | 0        | –    | %/°C     |

[1] Typical data is at  $T_A = 25^\circ C$  and  $V_{CC} = 12 V$ , unless otherwise noted; for design information only.

[2] Magnetic flux density, B, is indicated as a negative value for north-polarity magnetic fields, and a positive value for south-polarity magnetic fields.

**THERMAL CHARACTERISTICS:** May require derating at maximum conditions; see application information

| Characteristic             | Symbol          | Notes   | Rating | Unit |
|----------------------------|-----------------|---|--------|------|
| Package Thermal Resistance | $R_{\theta JA}$ | Package LH, 1-layer PCB with copper limited to solder pads  | 228    | °C/W |
|                            |                 | Package LH, 2-layer PCB with 0.463 in. <sup>2</sup> of copper area, each side connected by thermal vias | 110    | °C/W |
|                            |                 | Package UA, 1-layer PCB with copper limited to solder pads  | 165    | °C/W |



FUNCTIONAL DESCRIPTION

Operation

The output of these devices switches when a magnetic field perpendicular to the Hall-effect sensor exceeds the operate point threshold ( $B_{OP}$ ). When the magnetic field is reduced below the release point,  $B_{RP}$ , the device output switches to the alternate state. The output state (polarity) and magnetic field polarity depends on the selected device options. For unipolar south, an increasing south field is required; likewise, for unipolar north, an increasing north field is required to exceed  $B_{OP}$ . The output state is a configuration option.

The difference in magnetic operate and release points is the hysteresis,  $B_{HYS}$ , of the device. This built-in hysteresis allows clean switching of the output even in the presence of external mechani-

cal vibration and electrical noise. Figure 3 shows the output switching behavior relative to increasing and decreasing magnetic field. On the horizontal axis, the  $B+$  direction indicates increasing south polarity magnetic field strength. Figure 2 shows the sensing orientation of the magnetic field, relative to the device package.

The difference between operate ( $B_{OP}$ ) and release ( $B_{RP}$ ) points is the hysteresis,  $B_{HYS}$ . Hysteresis allows clean switching of the output even in the presence of external mechanical vibration and electrical noise.

Figure 3 shows the potential unipolar and omnipolar options and output polarity options the APS11800 can be configured for. The direction of the applied magnetic field is perpendicular to the branded face of the APS11800.

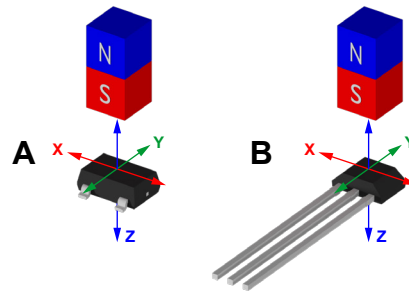


Figure 2: Magnetic Sensing Orientations  
LH Package (Panel A), UA Package (Panel B)



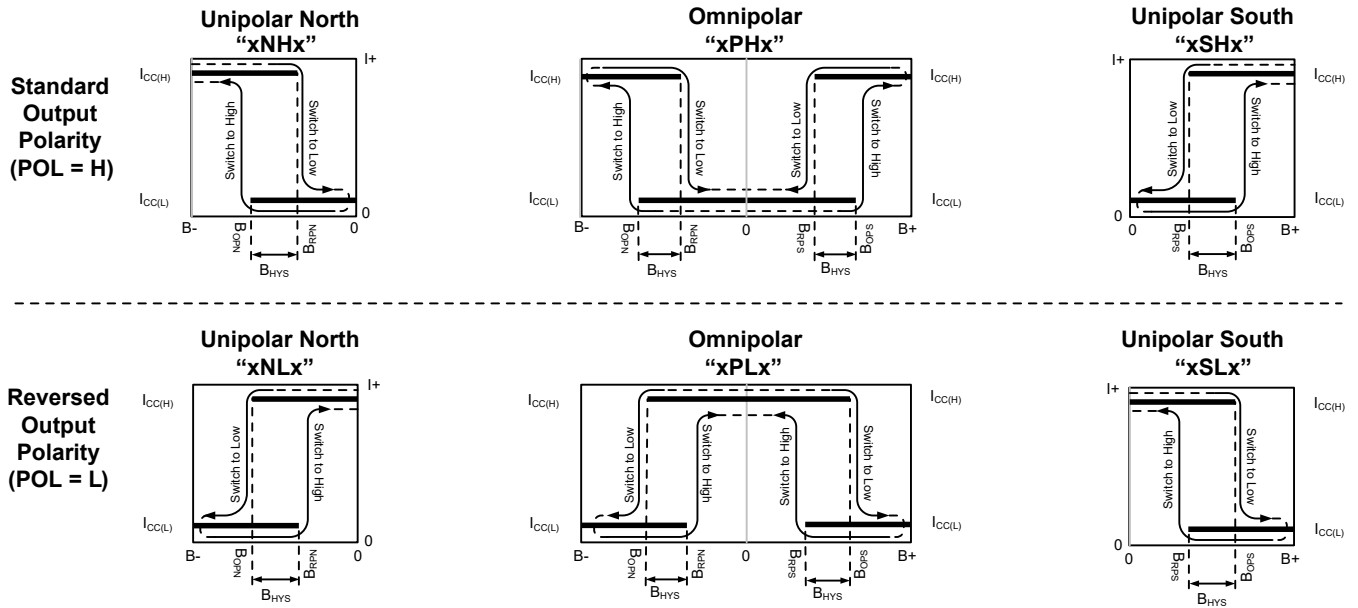


Figure 3: Hall Switch Output State vs. Magnetic Field

B- indicates increasing north polarity magnetic field strength, and B+ indicates increasing south polarity magnetic field strength.

**Power-On/Off Behavior**

During power up when  $V_{CC}$  reaches  $V_{CC(min)}$ , the output will enter Power-On State and stay there until  $t_{PO}$  expires. The  $t_{PO}$  timer starts as soon as  $V_{CC}$  exceeds  $V_{CC(min)}$ ; once  $t_{PO}$  expires, the device output is determined by the  $B_{OP}/B_{RP}$  specifications. (Note the minimum allowed power  $V_{CC}$  slew rate is 6 V/ms to ensure that  $V_{CC}$  has reached  $V_{CC(min)}$  within  $t_{PO}$ ).

After the device is powered up, if  $V_{CC}$  drops below  $V_{CC(min)}$ , the output state will continue to function; however,  $B_{OP}/B_{RP}$  speci-

fications are not be guaranteed over temperature and process corners when  $V_{UVLO} < V_{CC} < V_{CC(min)}$ . As soon as  $V_{CC}$  exceeds  $V_{CC(min)}$ ,  $B_{OP}/B_{RP}$  limits will be guaranteed over process and temperature. See Figure 5. If  $V_{CC}$  continues to drop below the UVLO threshold, the device output will be forced to POS ( $I_{CC(H)}$ ) and will remain there as long as  $V_{PD} < V_{CC} \leq V_{CC(min)}$ . Once  $V_{CC}$  has dropped below  $V_{UVLO}$ , the device will go through power-up sequence once  $V_{CC}$  is restored. If  $V_{CC}$  continues to drop below  $V_{PD}$ , the device will power down and the output will not be functional until  $V_{CC}$  is restored to be  $>V_{CC(min)}$ .

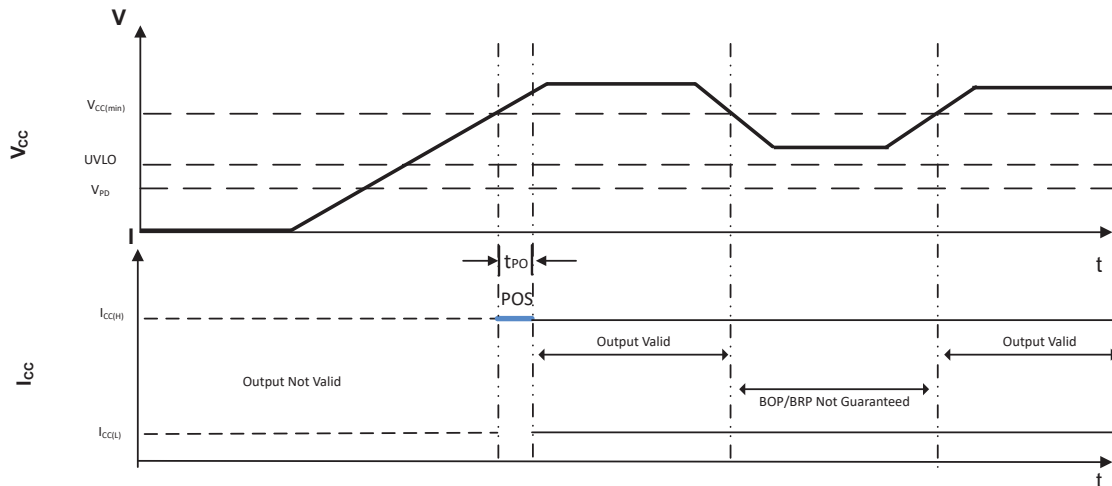


Figure 4: Device power up and subsequent restart after falling below  $V_{CC(min)}$  but not below  $V_{UVLO}$

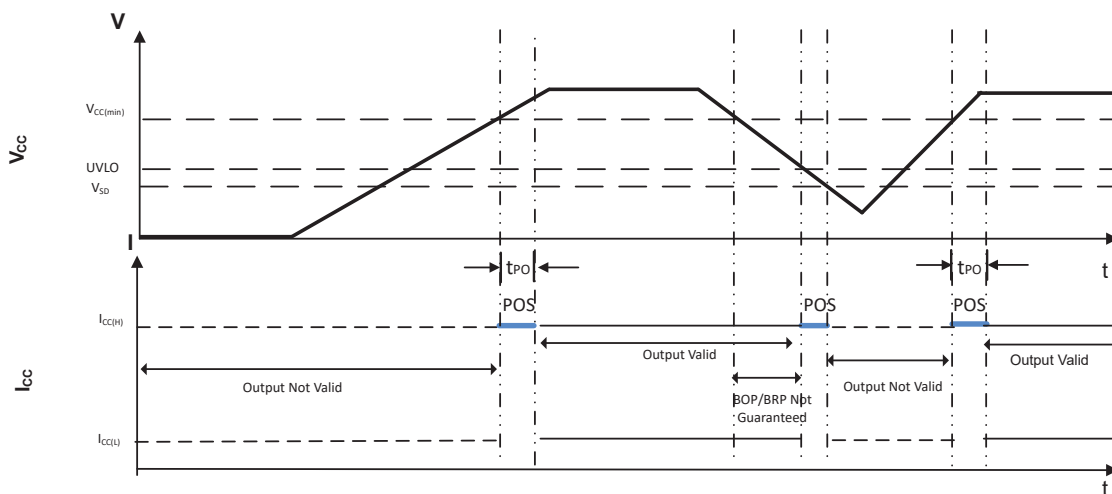


Figure 5: Device power up and subsequent reset after  $V_{CC}$  falls below  $V_{UVLO}$

**Two-Wire Interface**

The regulated current output is configured for two-wire applications, requiring one less wire for operation than switches with the traditional open-collector output. Additionally, the two-wire interface provides basic diagnostics to the system by monitoring the supply current. During normal operation, the supply current should operate in the specified ranges; see Figure 6. Any current level not within the specified operating ranges for  $I_{CC(H)}$  or  $I_{CC(L)}$  indicates a fault condition.

There are a couple specific fault conditions indicated by  $I_{CC} = I_{FAULT}$ . If the device junction temperature exceeds  $T_{JF}$ , average

supply current will be in the  $I_{FAULT}$  region. Additionally, if the any of the device internal diagnostics described in Table 1 detect a fault, the output will go to  $I_{FAULT}$ . A supply current greater than the specified maximum for the high level ( $I_{CC} > I_{CC(H)(max)}$ ), typically indicates a short condition.  $I_{CC} < I_{FAULT(min)}$  typically indicates an open circuit condition.

This unique two-wire interface protocol is backward compatible with legacy systems using two-wire switches. Additionally, the low fault mode supply current resulting from an internal fault will fall outside of the low and high supply current ranges and can be similarly identified as a sensor fault.

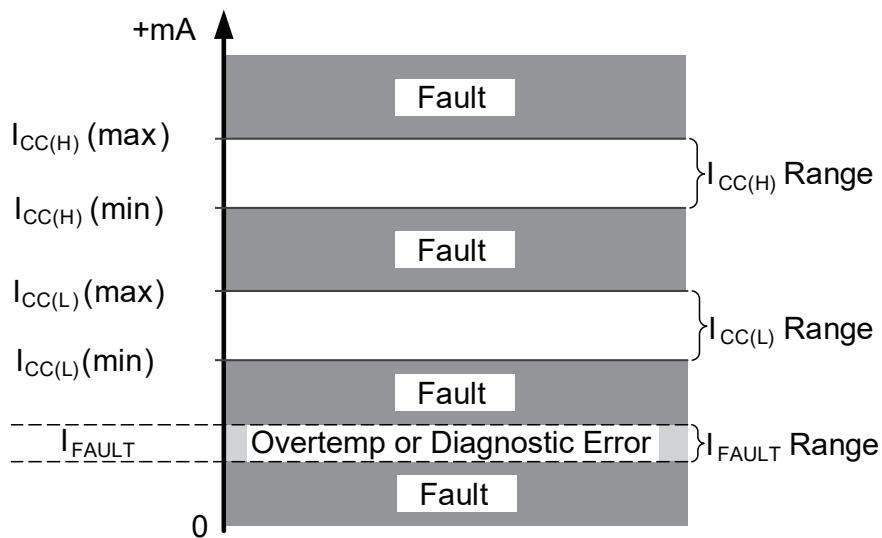


Figure 6: Two-Wire Interface Output

## Functional Safety

The APS11800 was developed in accordance with the international standard for automotive functional safety, ISO 26262:2011. Designed to meet ASIL B requirements when integrated and used in conjunction with the appropriate system level control, in the manner prescribed in the APS11800 Safety Manual.

The APS11800 features a proprietary diagnostics routine to support ASIL B safety requirements; see Table 1 and Figure 7. This internal diagnostics routine continuously runs in the background, monitoring all key subsystems of the IC. The diagnostic scheme runs at high speed and provides minimal impact on device performance.

The Hall element biasing circuit and voltage regulator are checked for valid operation, and the digital and nonvolatile memory blocks are checked for valid device configuration.

All diagnostics are running in real time in the background, allowing for a fault reaction time of approximately 44  $\mu$ s. The signal

path monitoring system verifies two internal state transitions ( $B_{OP}$  and  $B_{RP}$  within limits) under normal operation. In cases when these output transitions do not occur, or if another internal fault is detected, the output will go to the safe state.

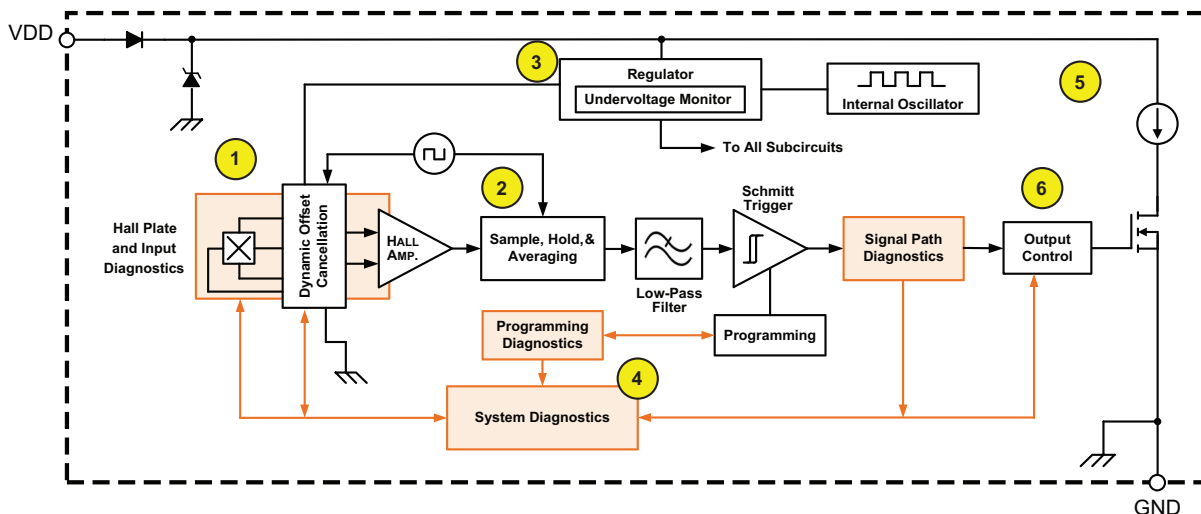
In the event of an internal fault, the device will continuously run the diagnostics routine every 2 ms ( $t_{DIAGF}$ ). The periodic recovery attempt sequence allows the device to continually check for the presence of a fault and return to normal operation if the fault condition clears.

In the case where the fault is no longer present, the output will resume normal operation. However, if the fault is persistent, the device will not exit fault mode and  $I_{CC}$  will continue to be  $I_{FAULT}$ . See Figure 8.

When a system rating higher than ASIL B is required, additional external safety measures may be employed (e.g., sensor redundancy and rationality checks, etc.). Refer to the device safety manual for additional details about the diagnostics.

**Table 1: Diagnostics Coverage**

|   | Feature           | Coverage   |
|---|-------------------|--|
| 1 | Hall plate        | Connectivity and biasing of Hall plate                     |
| 2 | Signal path       | Signal path and Schmitt trigger                            |
| 3 | Voltage regulator | Regulator voltage for normal operation                     |
| 4 | Digital subsystem | Digital subsystem and non-volatile memory                  |
| 5 | Entire system     | Overtemperature and redundancies for single point failures |
| 6 | Output            | Output verified with external monitors                     |



**Figure 7: Device Functional Block Diagram with Diagnostic Features Indicated**

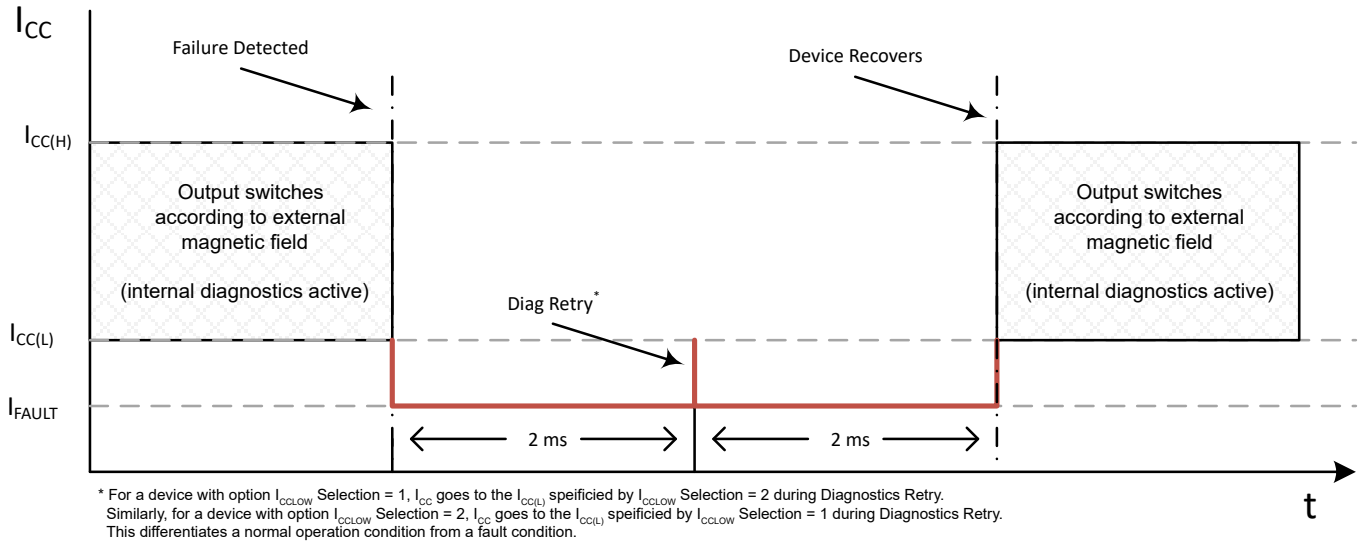


Figure 8: Diagnostic mode operation and timing during normal operation and during a fault condition

APPLICATIONS INFORMATION

Typical Applications

For the LH and UA, an external bypass capacitor,  $C_{BYP}$  should be connected as close as possible to the Hall sensor between the supply and ground to reduce noise. See Figure 9.

Temperature Coefficient and Magnet Selection

The APS11800 incorporates circuitry to compensate the magnetic switch points over the operating temperature range. This feature is referred to as the magnetic switch point temperature coefficient. The default option is for flat stable response over temperature. If the application requires compensation for temperature drifts common with NdFeB and ferrite magnets, contact Allegro MicroSystems. It is recommended that system designers evaluate their magnetic circuit over the expected operating temperature range to ensure the magnetic switching requirements are met.

Extensive applications information on magnets and Hall-effect sensors is available in:

- *Hall-Effect IC Applications Guide, AN27701,*
- *Hall-Effect Devices: Guidelines For Designing Subassemblies Using Hall-Effect Devices AN27703.1*
- *Soldering Methods for Allegro's Products – SMT and Through-Hole, AN26009*
- Functional Safety Challenges to the Automotive Supply Chain (<http://www.allegromicro.com/en/Design-Center/Technical-Documents/General-Semiconductor-Information/Functional-Safety-Challenges-Automotive-Supply-Chain.aspx>)

All are provided on the Allegro website:

[www.allegromicro.com](http://www.allegromicro.com)

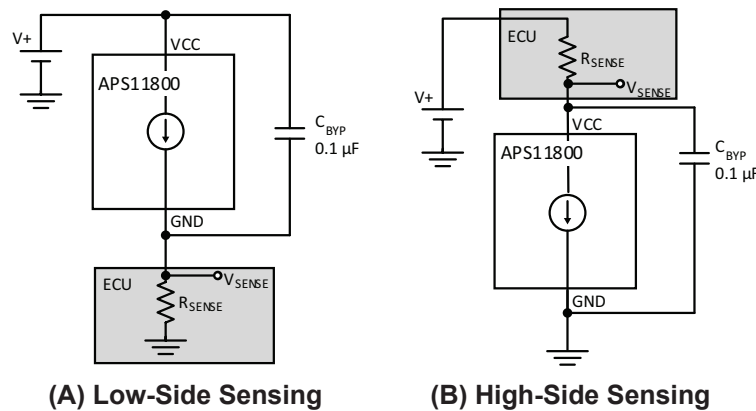


Figure 9: Typical Application Circuits

CHOPPER STABILIZATION

A limiting factor for switch point accuracy when using Hall-effect technology is the small-signal voltage developed across the Hall plate. This voltage is proportionally small relative to the offset that can be produced at the output of the Hall sensor. This makes it difficult to process the signal and maintain an accurate, reliable output over the specified temperature and voltage range. Chopper stabilization is a proven approach used to minimize Hall offset.

The technique, dynamic quadrature offset cancellation, removes key sources of the output drift induced by temperature and package stress. This offset reduction technique is based on a signal modulation-demodulation process. Figure 10: Model of Chopper Stabilization Circuit (Dynamic Offset Cancellation) illustrates how it is implemented.

The undesired offset signal is separated from the magnetically induced signal in the frequency domain through modulation.

The subsequent demodulation acts as a modulation process for the offset, causing the magnetically induced signal to recover its original spectrum at baseband while the DC offset becomes a high-frequency signal. Then, using a low-pass filter, the signal passes while the modulated DC offset is suppressed.

Allegro’s innovative chopper stabilization technique uses a high-frequency clock. The high-frequency operation allows a greater sampling rate that produces higher accuracy, reduced jitter, and faster signal processing. Additionally, filtering is more effective and results in a lower noise analog signal at the sensor output. Devices such as the APS11800 that use this approach have a stable quiescent Hall output voltage, are immune to thermal stress, and have precise recoverability after temperature cycling. This technique is made possible through the use of a BiCMOS process which allows the use of low-offset and low-noise amplifiers in combination with high-density logic and sample-and-hold circuits.

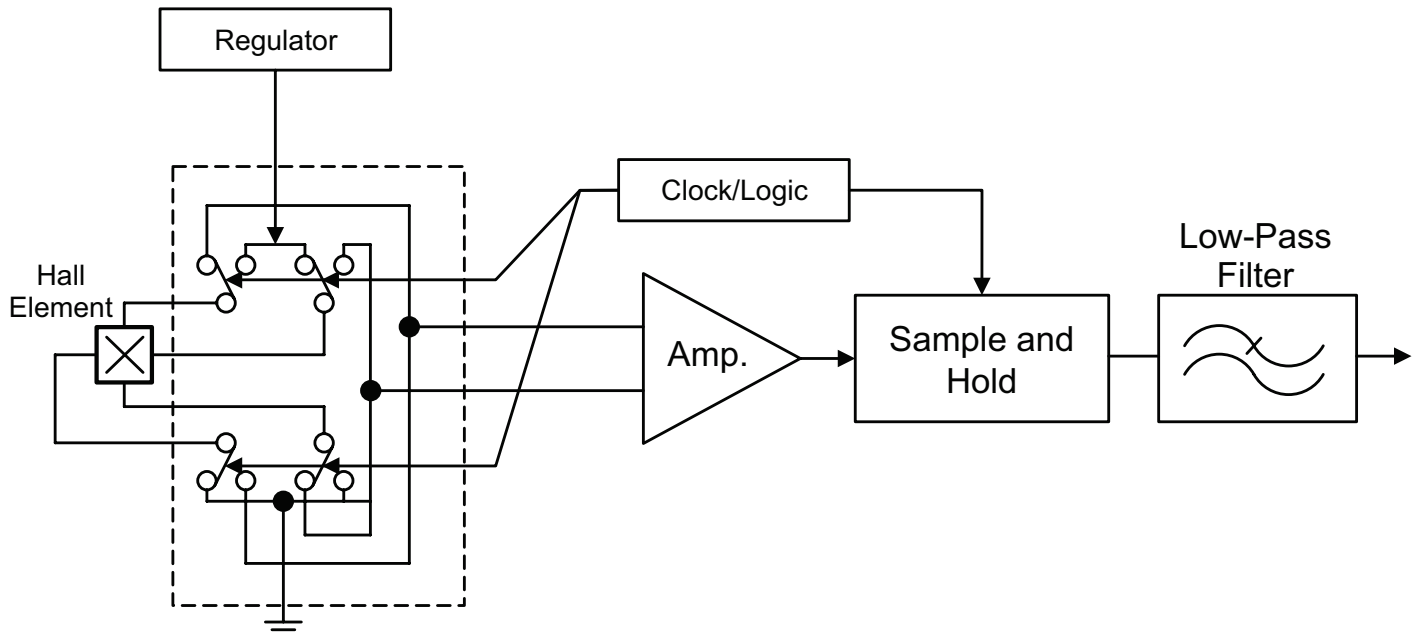


Figure 10: Model of Chopper Stabilization Circuit (Dynamic Offset Cancellation)

POWER DERATING

The device must be operated below the maximum junction temperature,  $T_J$  (max). Reliable operation may require derating supplied power and/or improving the heat dissipation properties of the application.

Thermal Resistance (junction to ambient),  $R_{\theta JA}$ , is a figure of merit summarizing the ability of the application and the device to dissipate heat from the junction (die), through all paths to ambient air.  $R_{\theta JA}$  is dominated by the Effective Thermal Conductivity,  $K$ , of the printed circuit board which includes adjacent devices and board layout. Thermal resistance from the die junction to case,  $R_{\theta JC}$ , is a relatively small component of  $R_{\theta JA}$ . Ambient air temperature,  $T_A$ , and air motion are significant external factors in determining a reliable thermal operating point.

The following three equations can be used to determine operation points for given power and thermal conditions.

$$P_D = V_{IN} \times I_{IN} \tag{1}$$

$$\Delta T = P_D \times R_{\theta JA} \tag{2}$$

$$T_J = T_A + \Delta T \tag{3}$$

For example, given common conditions:  $T_A = 25^\circ C$ ,  $V_{CC} = 12 V$ ,  $I_{CC} = 17 mA$ , and  $R_{\theta JA} = 110^\circ C/W$  for the LH package, then:

$$P_D = V_{CC} \times I_{CC} = 12 V \times 17 mA = 204 mW$$

$$\Delta T = P_D \times R_{\theta JA} = 204 mW \times 110^\circ C/W = 22.44^\circ C$$

$$T_J = T_A + \Delta T = 25^\circ C + 22.44^\circ C = 47.44^\circ C$$

Determining Maximum  $V_{CC}$

For a given ambient temperature,  $T_A$ , the maximum allowable power dissipation as a function of  $V_{CC}$  can be calculated.  $P_D$  (max) represents the maximum allowable power level without exceeding  $T_J$  (max) at a selected  $R_{\theta JA}$  and  $T_A$ .

Example:  $V_{CC}$  at  $T_A = 150^\circ C$ , package UA, using low-K PCB. Using the worst-case ratings for the device, specifically:  $R_{\theta JA} = 165^\circ C/W$ ,  $T_J$  (max) =  $165^\circ C$ ,  $V_{CC}$  (max) =  $24 V$ , and  $I_{CC}$  (max) =

$17 mA$ , calculate the maximum allowable power level,  $P_D$  (max). First, using equation 3:

$$\Delta T (max) = T_J (max) - T_A = 165^\circ C - 150^\circ C = 15^\circ C$$

This provides the allowable increase to  $T_J$  resulting from internal power dissipation. Then, from equation 2:

$$P_D (max) = \Delta T (max) \div R_{\theta JA} = 15^\circ C \div 165^\circ C/W = 91 mW$$

Finally, using equation 1, solve for maximum allowable  $V_{CC}$  for the given conditions:

$$V_{CC} (est) = P_D (max) \div I_{CC} (max) = 91 mW \div 17 mA = 5.4 V$$

The result indicates that, at  $T_A$ , the application and device can dissipate adequate amounts of heat at voltages  $\leq V_{CC}$  (est).

If the application requires  $V_{CC} > V_{CC(est)}$  then  $R_{\theta JA}$  must be improved. This can be accomplished by adjusting the layout, PCB materials, or by controlling the ambient temperature.

Determining Maximum  $T_A$

In cases where the  $V_{CC}$  (max) level is known, and the system designer would like to determine the maximum allowable ambient temperature  $T_A$  (max), for example, in a worst-case scenario with conditions  $V_{CC}$  (max) =  $24 V$ ,  $I_{CC}$  (max) =  $17 mA$ , and  $R_{\theta JA} = 228^\circ C/W$  for the LH package using equation 1, the largest possible amount of dissipated power is:

$$P_D = V_{IN} \times I_{IN}$$

$$P_D = 24 V \times 17 mA = 408 mW$$

Then, by rearranging equation 3 and substituting with equation 2:

$$T_A (max) = T_J (max) - \Delta T$$

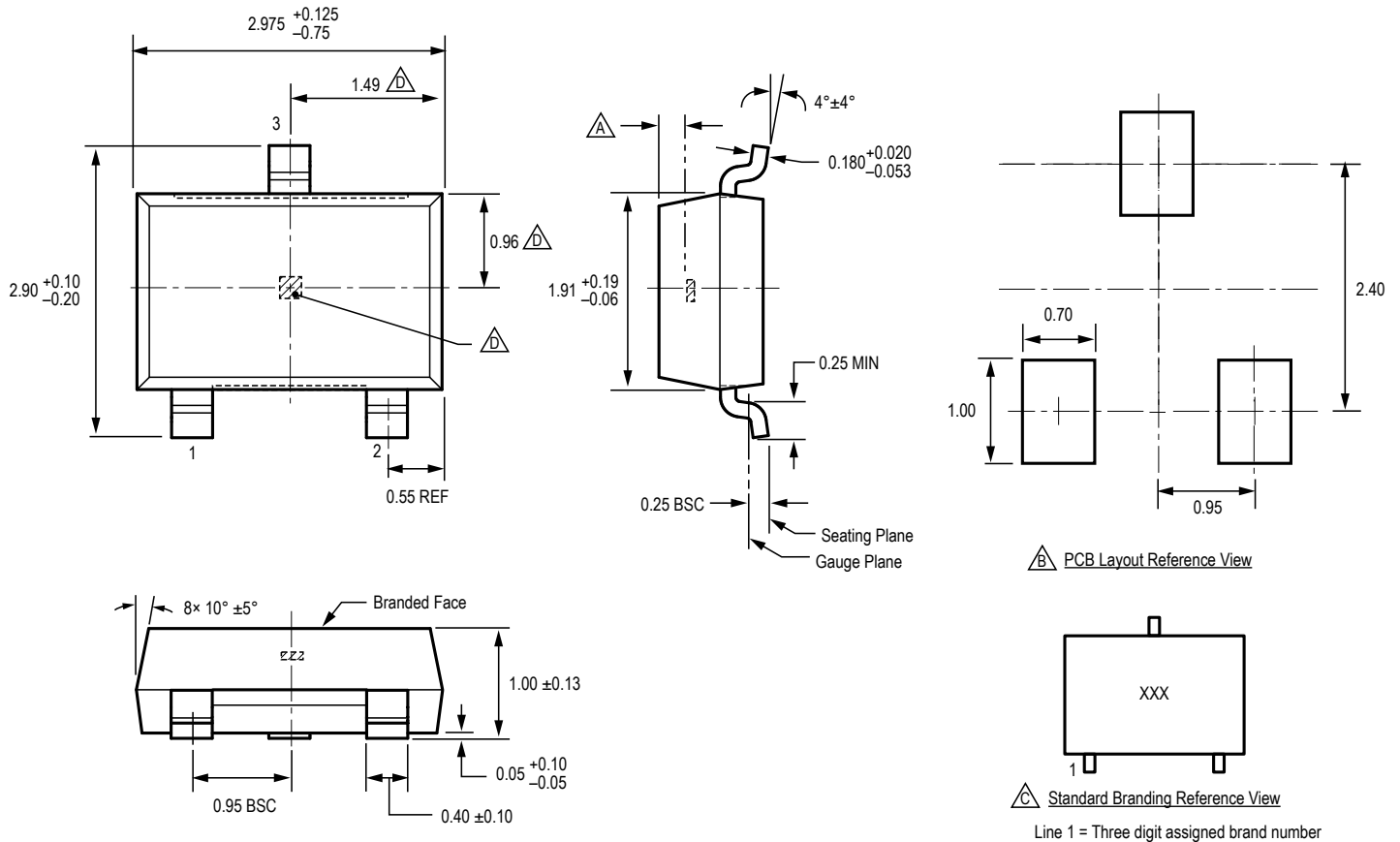
$$T_A (max) = 165^\circ C - (408 mW \times 228^\circ C/W)$$

$$T_A (max) = 165^\circ C - 93^\circ C = 72^\circ C$$

Finally, note that the  $T_A$  (max) rating of the device is  $150^\circ C$  and performance is not guaranteed above this temperature for any power level.



PACKAGE OUTLINE DRAWINGS



For reference only; not for tooling use (reference DWG-0000628, Rev. 1).  
 Dimensions in millimeters.  
 Dimensions exclusive of mold flash, gate burrs, and dambar protrusions.  
 Exact case and lead configuration at supplier discretion within limits shown.

- $\triangle A$  Active Area Depth,  $0.28 \pm 0.04 \text{ mm}$
- $\triangle B$  Reference land pattern layout  
 All pads a minimum of  $0.20 \text{ mm}$  from all adjacent pads; adjust as necessary to meet application process requirements and PCB layout tolerances
- $\triangle C$  Branding scale and appearance at supplier discretion
- $\triangle D$  Hall element, not to scale

Figure 11: Package LH, 3-Pin SOT23W

For Reference Only – Not for Tooling Use

(Reference DWG-0000619, Rev. 1)

NOT TO SCALE

Dimensions in millimeters

Dimensions exclusive of mold flash, gate burrs, and dambar protrusions

Exact case and lead configuration at supplier discretion within limits shown

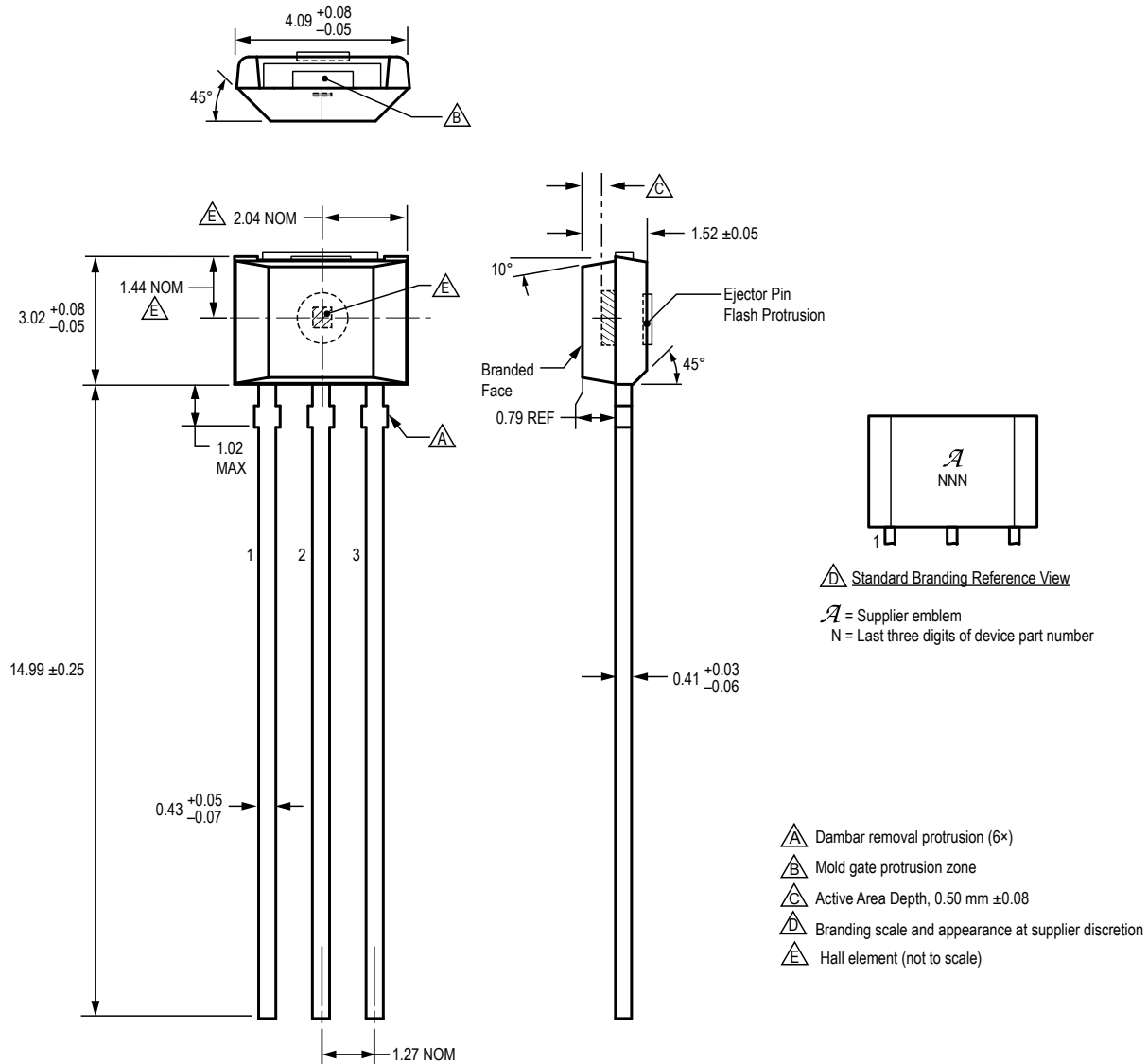


Figure 12: Package UA, 3-Pin SIP

**Revision History**

| Number | Date           | Description     |
|--------|----------------|-----------------|
| –      | March 24, 2020 | Initial release |

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